

CLAIMS

What is claimed is:

1. A method for operating a gas-agitated fluidized bed hydrocarbon synthesis reactor, wherein the fluidized bed comprises catalyst particles that are prone to slumping at times when an insufficient rate of gas is supplied to the fluidized bed, the method comprising:
 - (A) providing the gas-agitated hydrocarbon synthesis reactor comprising a catalyst bed and a gas injection zone, wherein the catalyst bed comprises catalyst particles, and wherein the gas injection zone is suitable for injecting a reactor gas feed with a reactor gas feed flow rate to the catalyst bed, and further wherein the gas injection zone comprises at least one gas distributor;
 - (B) selecting a reference flow rate that is sufficient to disperse substantially all of the catalyst particles in the catalyst bed;
 - (C) passing a reactor gas supply from the at least one gas distributor in the gas injection zone through the catalyst bed, wherein the reactor gas supply comprises at least a portion of the reactor gas feed; and
 - (D) supplying a supplemental gas to the gas injection zone when the reactor gas feed flow rate becomes less than the reference flow rate.
2. The method of claim 1, wherein the reactor gas supply in step (C) comprises a reactant gas.
3. The method of claim 2, wherein at least a portion of the catalyst particles are active for Fischer-Tropsch synthesis, and wherein the reactant gas comprises carbon monoxide and hydrogen.

4. The method of claim 3, wherein step (C) is performed under reaction promoting conditions so as to convert at least a portion of the reactant gas to hydrocarbon products.
5. The method of claim 4, wherein reaction promoting conditions comprise a temperature between about 185°C and about 300°C.
6. The method of claim 1, wherein the supplemental gas comprises at least one gas selected from the group consisting of hydrocarbons having 5 carbon atoms or less, natural gas, argon, nitrogen, hydrogen, carbon dioxide, and combinations thereof.
7. The method of claim 1, wherein step (C) is performed under non-reactive conditions so that substantially all of the reactor gas feed is unconverted while passing through the gas-agitated multiphase reactor.
8. The method of claim 7, wherein non-reactive conditions comprise a temperature less than 180°C.
9. The method of claim 7, wherein the reactor gas supply comprises at least one gas selected from the group consisting of hydrocarbons having 5 carbon atoms or less, natural gas, argon, nitrogen, hydrogen, carbon dioxide, and combinations thereof.

10. The method of claim 1, wherein the supplemental gas is supplied to provide a reactor gas feed flow rate equal to or greater than the reference flow rate.
11. The method of claim 1, wherein the reference flow rate of step (D) comprises a minimum fluidization velocity.
12. The method of claim 11, wherein step (D) further comprises supplying the supplemental gas to the reactor when the reactor gas supply has a reactor gas supply flow rate less than, about equal to, or within a desired range of the minimum fluidization velocity.
13. The method of claim 1, further comprising
 - (E) recycling at least a portion of the supplemental gas to the reactor.
14. The method of claim 1, wherein the reactor gas supply and the supplemental gas are supplied separately by at least two different gas distributors.
15. The method of claim 1, wherein the reactor gas supply and the supplemental gas are supplied by one gas distributor.
16. The method of claim 1, wherein step (D) further comprises measuring the reactor gas feed flow rate, and further comprises comparing the measured reactor gas feed flow rate to the reference flow rate.

17. The method of claim 1, wherein the supplemental gas is substantially free of molecular oxygen.
18. The method of claim 1, wherein the supplemental gas is substantially free of sulfur.
19. The method of claim 1, further comprising
 - (E) reducing or shutting off the supply of the reactor gas supply.
20. The method of claim 1, further comprising
 - (E) separating the catalyst bed from the gas injection zone.
21. The method of claim 20, wherein step (E) further comprises separating the catalyst bed from the gas injection zone by a porous plate, wherein the porous plate comprises a plurality of perforations having open areas.
22. The method of claim 21, wherein at least a portion of the perforations comprise a size sufficient to substantially prevent plugging of the at least one gas distributor by the catalyst particles.
23. The method of claim 22, wherein about each catalyst particle comprises a fresh size of from about 20 microns to about 200 microns.

24. The method of claim 23, wherein at least a portion of the perforations have a size of less than about 20 microns.

25. The method of claim 21, wherein at least a portion of the perforations have a size of less than about 20 microns.

26. The method of claim 21, wherein about 90 percent by weight of the catalyst particles have a fresh size equal to or greater than the size of each perforation.

27. The method of claim 21, wherein the porous plate has a cross-sectional area, and wherein the perforations comprise a total open area of from about 10 to about 90 percent of the cross-sectional area of the porous plate.

28. The method of claim 21, wherein the gas-agitated hydrocarbon synthesis reactor comprises a cross-sectional area, and wherein the porous plate comprises a cross-sectional area from about 10 to about 100 percent of the cross-sectional area of the gas-agitated multiphase reactor.

29. A method for operating a gas-agitated hydrocarbon synthesis reactor having a bed of catalyst elements that are prone to slumping at times of insufficient gas flow into the reactor, the method comprising:

- (A) providing the gas-agitated hydrocarbon synthesis reactor comprising a catalyst bed and a gas injection zone, wherein the catalyst bed comprises catalyst particles, and wherein the gas injection zone is suitable for injecting a reactor gas feed to said catalyst bed, and further wherein the gas injection zone comprises at least one gas distributor;
- (B) selecting a reference flow rate, wherein the reference flow rate is sufficient to disperse substantially all of the catalyst particles in the catalyst bed;
- (C) passing a gas stream with a gas stream flow rate from the at least one gas distributor in the gas injection zone through the catalyst bed; and
- (D) supplying a supplemental gas from the injection zone to the catalyst bed at a time of insufficient flow of said gas stream so as to achieve a total reactor gas feed flow rate equal to or greater than the reference flow rate, wherein the total reactor gas feed flow rate comprises the flow rate of said gas stream and the flow rate of supplemental gas.

30. A method of operating a gas-agitated multiphase reactor having catalyst elements that are prone to slumping at times of insufficient gas flow through the multiphase reactor, the method comprising:

- (A) supplying a reactant gas at a reactant gas flow rate to the gas-agitated multiphase reactor;
- (B) measuring the reactant gas supply flow rate;
- (C) comparing the measured flow rate of the reactant gas to a reference flow rate; and
- (D) supplying a supplemental gas to the gas-agitated multiphase reactor when the reactant gas flow rate falls below said reference flow rate so as to provide a total gas flow rate above the reference flow rate wherein the total gas flow rate is the combination of reactant gas and supplemental gas being supplied to the reactor.

31. The method of claim 30, wherein the gas-agitated multiphase reactor is sufficient for Fischer-Tropsch synthesis.

32. The method of claim 30, wherein the reactant gas comprises hydrogen and carbon monoxide.

33. The method of claim 30, wherein the supplemental gas has a flow rate, and wherein step (D) further comprises regulating the supplemental gas flow rate so as to provide to the gas-agitated multiphase reactor a total gas flow rate of reactant gas and supplemental gas about equal to or greater than the reference flow rate.

34. The method of claim 30, wherein the reference flow rate of step (C) comprises a minimum fluidization velocity.
35. The method of claim 34, wherein step (D) further comprises supplying the supplemental gas to the gas-agitated multiphase reactor when the measured flow rate of the reactant gas is less than or about equal to the minimum fluidization velocity.
36. The method of claim 30, wherein step (D) further comprises supplying the supplemental gas to the gas-agitated multiphase reactor when the measured flow rate of the reactant gas is less than or about equal to the reference flow rate.
37. The method of claim 30, wherein the supplemental gas comprises at least one gas selected from the group consisting of any hydrocarbon having 5 carbon atoms or less, natural gas, argon, nitrogen, hydrogen, carbon dioxide, and any combinations thereof.
38. The method of claim 30, wherein the supplemental gas is substantially free of molecular oxygen.
39. The method of claim 30, wherein the supplemental gas is substantially free of sulfur.
40. The method of claim 30, further comprising
- (E) separating at least one reaction zone from a gas injection zone, wherein steps (A) and (D) are performed by at least one gas distributor in the gas injection zone.

41. The method of claim 40, wherein step (E) further comprises separating the at least one reaction zone from the gas injection zone by a porous plate, wherein the porous plate comprises a plurality of perforations having open areas.

42. The method of claim 41, wherein at least a portion of the perforations comprise a size sufficient to substantially prevent plugging of the at least one gas distributor by catalyst particles.

43. The method of claim 41, wherein about each catalyst particle comprises a fresh size of from about 20 microns to about 200 microns.

44. The method of claim 43, wherein at least a portion of the perforations have a size of less than about 20 microns.

45. The method of claim 41, wherein at least a portion of the perforations have a size of less than about 20 microns.

46. The method of claim 41, wherein about 90 percent by weight of the catalyst particles have a fresh size equal to or greater than the size of each perforation.

47. The method of claim 41, wherein the porous plate has a cross-sectional area, and wherein the perforations comprise a total open area of from about 10 to about 90 percent of the cross-sectional area of the porous plate.

48. The method of claim 41, wherein the gas-agitated hydrocarbon synthesis reactor comprises a cross-sectional area, and wherein the porous plate comprises a cross-sectional area from about 10 to about 100 percent of the cross-sectional area of the gas-agitated multiphase reactor.

49. The method of claim 30, further comprising

(E) recycling at least a portion of the supplemental gas to the gas-agitated hydrocarbon synthesis reactor.

50. The method of claim 30, wherein the reactant gas and the supplemental gas are supplied separately to the gas-agitated hydrocarbon synthesis reactor by at least two different gas distributors.

51. The method of claim 30, wherein the reactant gas and the supplemental gas are supplied by at least one gas distributor, and wherein the at least one gas distributor comprises at least one sparger, at least one nozzle, or combination thereof.

52. The method of claim 30, further comprising

(E) reducing or shutting off the supply of the reactant gas.

53. A method of operating a hydrocarbon synthesis reactor, wherein the hydrocarbon synthesis reactor comprises a plurality of catalyst particles suspended in a liquid and having gas agitating the particles and liquid so as to maintain a distribution of particles in the liquid and prevent the particles from slumping, the method comprising:

- (A) supplying a reactant gas to the hydrocarbon synthesis reactor, wherein the reactant gas is supplied to the hydrocarbon synthesis reactor in a gas injection zone, and wherein the reactant gas has a reactant gas supply flow rate to the hydrocarbon synthesis reactor;
- (B) reacting the reactant gas with the plurality of catalyst particles in a reaction zone;
- (C) measuring the reactant gas supply flow rate to the hydrocarbon synthesis reactor;
- (D) comparing the measured flow rate of the reactant gas to a reference flow rate; and
- (E) supplying a supplemental gas to the hydrocarbon synthesis reactor in the reaction zone, wherein the supplemental gas is supplied to the hydrocarbon synthesis reactor when the measured flow rate of the reactant gas falls below the reference flow rate, so as to provide to the hydrocarbon synthesis reactor a total gas flow rate of reactant gas and supplemental gas equal to or greater than the reference flow rate.

54. The method of claim 53, wherein the hydrocarbon synthesis reactor comprises a gas-agitated multiphase reactor.

55. The method of claim 53, wherein the reactant gas comprises hydrogen and carbon monoxide.

56. The method of claim 53, wherein the supplemental gas has a flow rate, and wherein step (E) further comprises regulating the supplemental gas flow rate to have the total gas flow rate to the hydrocarbon synthesis reactor about equal to or greater than the reference flow rate.
57. The method of claim 53, wherein the reference flow rate of step (D) comprises a minimum fluidization velocity.
58. The method of claim 53, wherein the supplemental gas comprises at least one gas selected from the group consisting of any hydrocarbons having 5 carbon atoms or less, natural gas, argon, nitrogen, hydrogen, carbon dioxide, and any combinations thereof.
59. The method of claim 53, wherein the supplemental gas is substantially free of molecular oxygen.
60. The method of claim 53, wherein the supplemental gas is substantially free of sulfur.
61. The method of claim 53, further comprising
(F) separating the reaction zone from the gas injection zone.
62. The method of claim 61, wherein step (F) further comprises separating the reaction zone from the gas injection zone by a porous plate, wherein the porous plate comprises a plurality of perforations having open areas.

63. The method of claim 62, wherein at least a portion of the perforations comprise a size sufficient to substantially prevent plugging of a gas distributor by catalyst particles.
64. The method of claim 62, wherein about each catalyst particle comprises a fresh size of from about 20 microns to about 200 microns.
65. The method of claim 62, wherein at least a portion of the perforations have a size of less than about 20 microns.
66. The method of claim 62, wherein about 90 percent by weight of the catalyst particles have a fresh size equal to or greater than the size of each perforation.
67. The method of claim 62, wherein the porous plate has a cross-sectional area, and wherein the perforations comprise a total open area of from about 10 to about 90 percent of the cross-sectional area of the porous plate.
68. The method of claim 62, wherein the porous plate comprises a cross-sectional area from about 10 to about 100 percent of a cross-sectional area of the hydrocarbon synthesis reactor.
69. The method of claim 53, further comprising
- (F) recycling at least a portion of the supplemental gas to the hydrocarbon synthesis reactor.

70. The method of claim 53, wherein the reactant gas and the supplemental gas are supplied separately to the hydrocarbon synthesis reactor by at least two different gas distributors.

71. The method of claim 53, wherein the reactant gas and the supplemental gas are supplied to the hydrocarbon synthesis reactor by at least one gas distributor.

72. The method of claim 53, further comprising:

(F) reducing or shutting off the supply of the reactant gas.